US006367323B1

(12) United States Patent
Camwell et al.

(10) Patent No.: US 6,367,323 B1

(45) Date of Patent: Apr. 9, 2002

(54) **DYNAMIC PRESSURE DEVICE FOR OIL DRILL SYSTEMS**

(75) Inventors: **Paul L. Camwell**; **Michael T. Sutherland**; **Anthony Robert Dopf**; **Derek W. Logan**; **Randall S. Liscombe**, all of Calgary (CA)

(73) Assignee: **Ryan Energy Technologies, Inc.**, Calgary (CA)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/641,092**

(22) Filed: **Aug. 17, 2000**

(51) **Int. Cl.**^{7} **E21B 47/00**; E21B 47/12

(52) **U.S. Cl.** **73/152.52**; 73/152.03

(58) **Field of Search** 73/152.48, 152.02, 73/152.03, 152.22, 152.51, 152.52; 166/297; 285/18

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,297,880 A 11/1981 Berger 73/155
4,805,449 A 2/1989 Das 73/151
4,919,454 A * 4/1990 Caulfield et al. 285/18
6,220,355 B1 * 4/2001 French 166/297

FOREIGN PATENT DOCUMENTS

CA 607352 10/1960

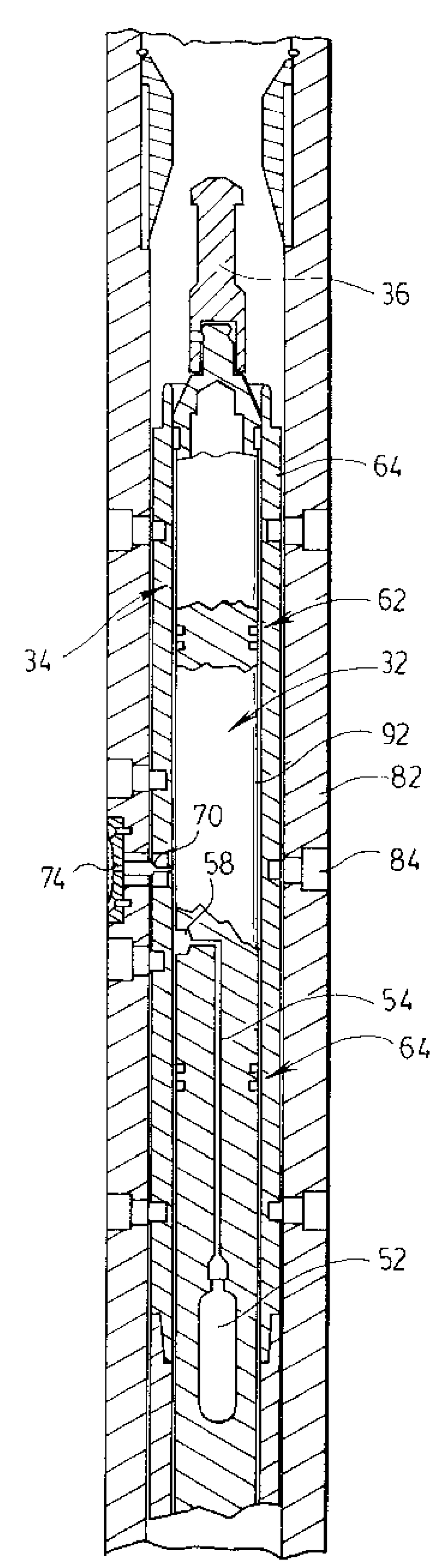
* cited by examiner

Primary Examiner—Hezron Williams
Assistant Examiner—Jay L. Politzer
(74) *Attorney, Agent, or Firm*—Lee, Mann, Smith, McWilliams Sweeney & Ohlson

(57) **ABSTRACT**

A drill string section for use in making up a drill string for oil and gas drilling carries instrumentation for measurement and logging while drilling. The instrumentation includes a dynamic pressure device for measuring drill string bore pressure of incoming pressurized fluid and drill string annular pressure of returned pressurized fluid. The drill string section comprises a length of drill string pipe having a bore defined by an inner surface of a wall which has an outer surface. The instrumentation is provided in an elongate cylindrical tool shell. The outer surface of the tool shell has spaced apart seals which engage the inside surface of a cylindrical landing sleeve in the pipe bore. The seals are located in the sleeve on either side of communicating port(s) in the drill pipe wall, forming a leak tight annular region that eventually communicates through appropriate ports to a pressure transducer.

13 Claims, 7 Drawing Sheets



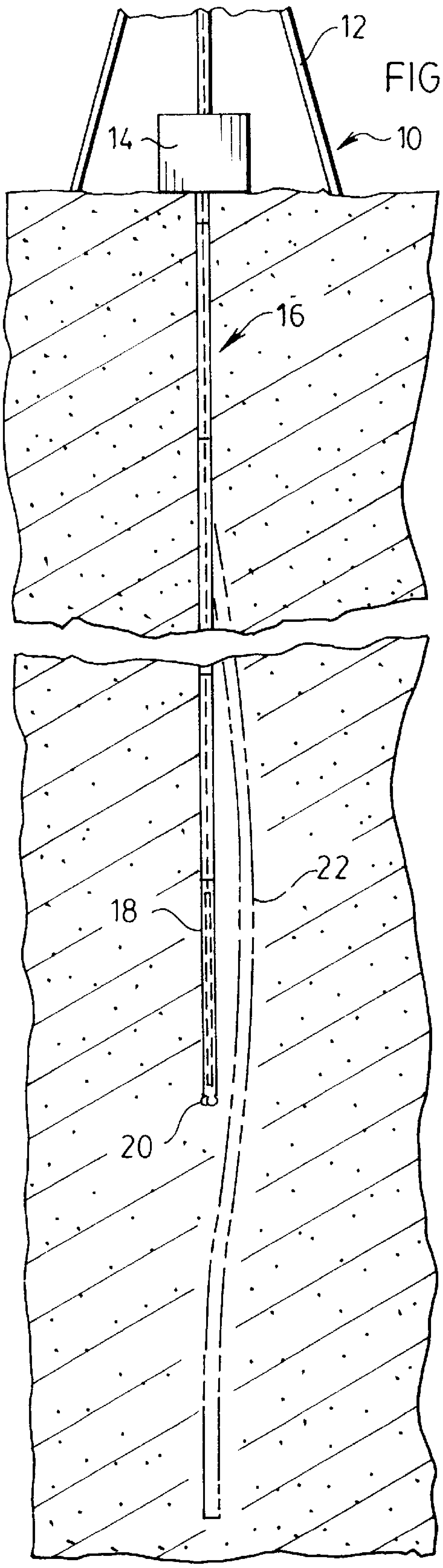

12
14
10
16
22
18
20

FIG.1.

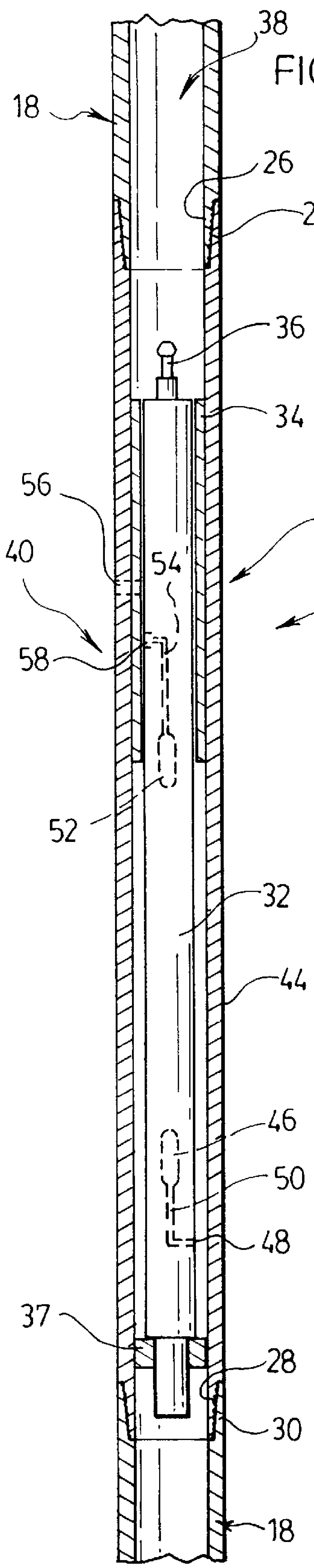

38
18
26
24
36
34
56
18
40
54
42
58
52
32
44
46
50
48
37
28
30
18

FIG.2.

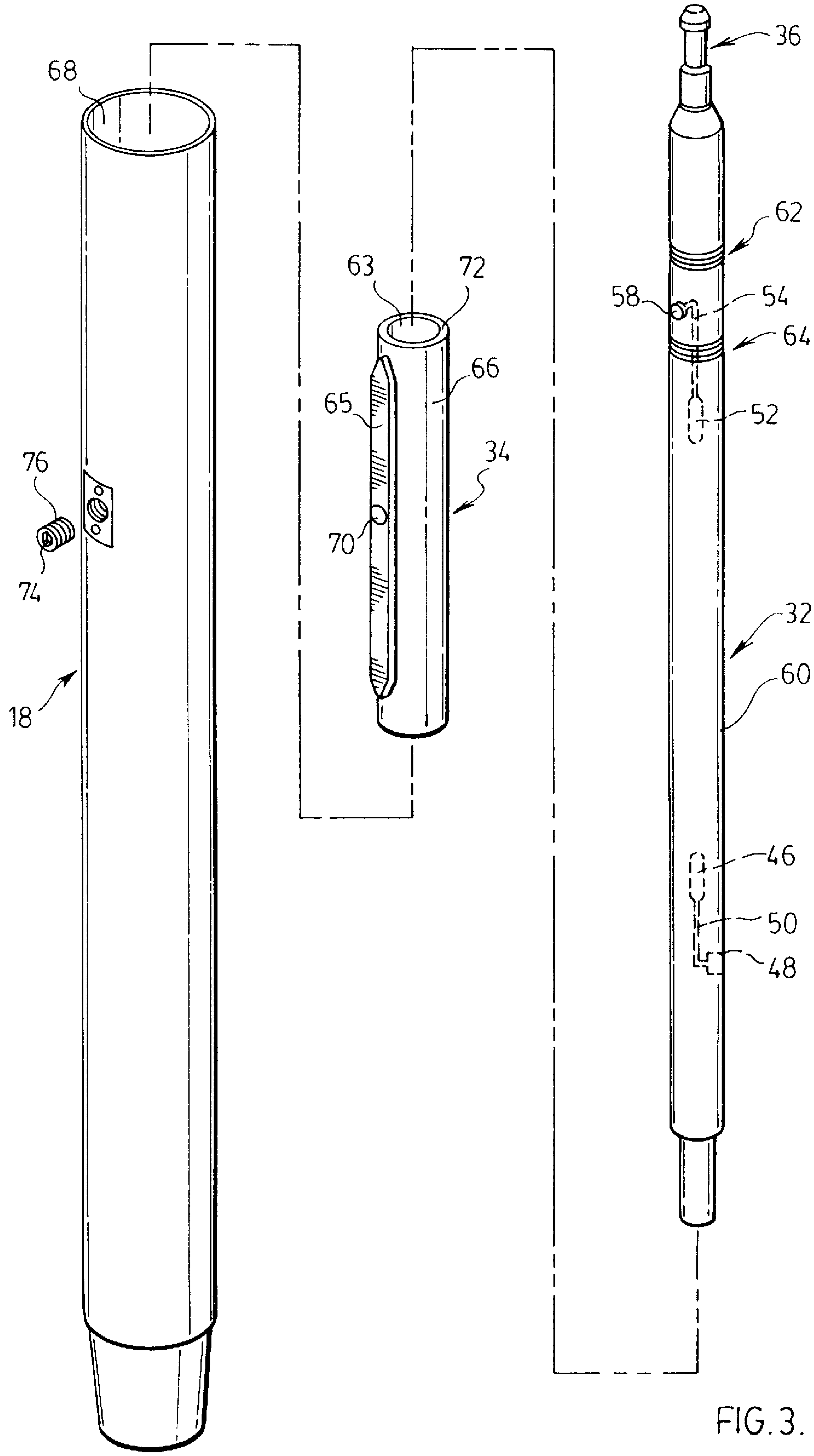


FIG. 3.

FIG.4.

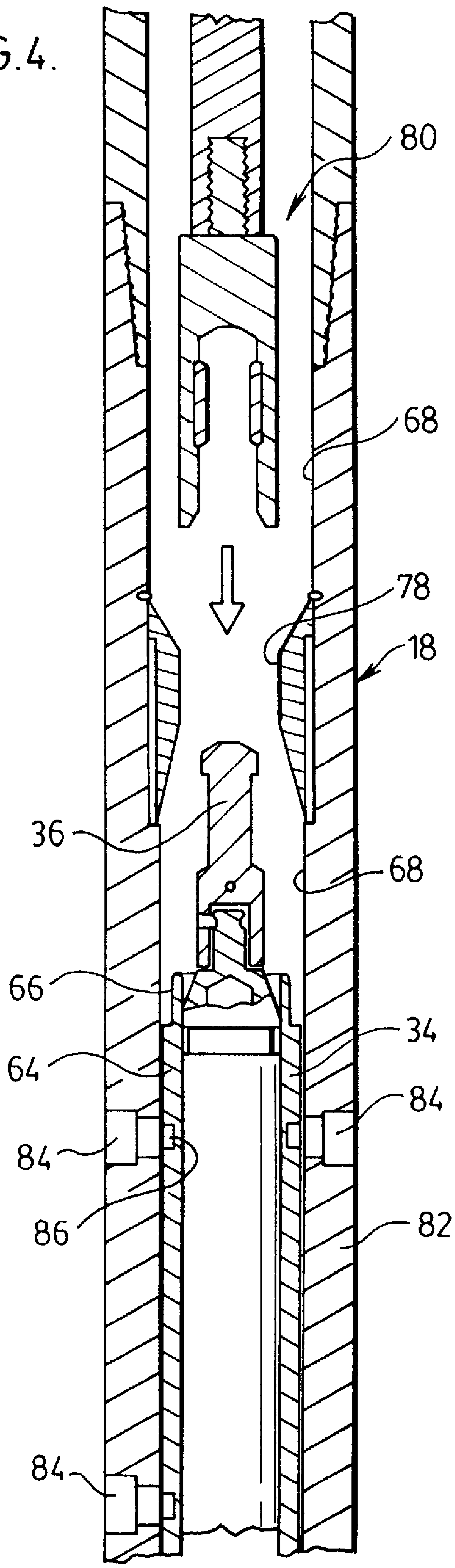
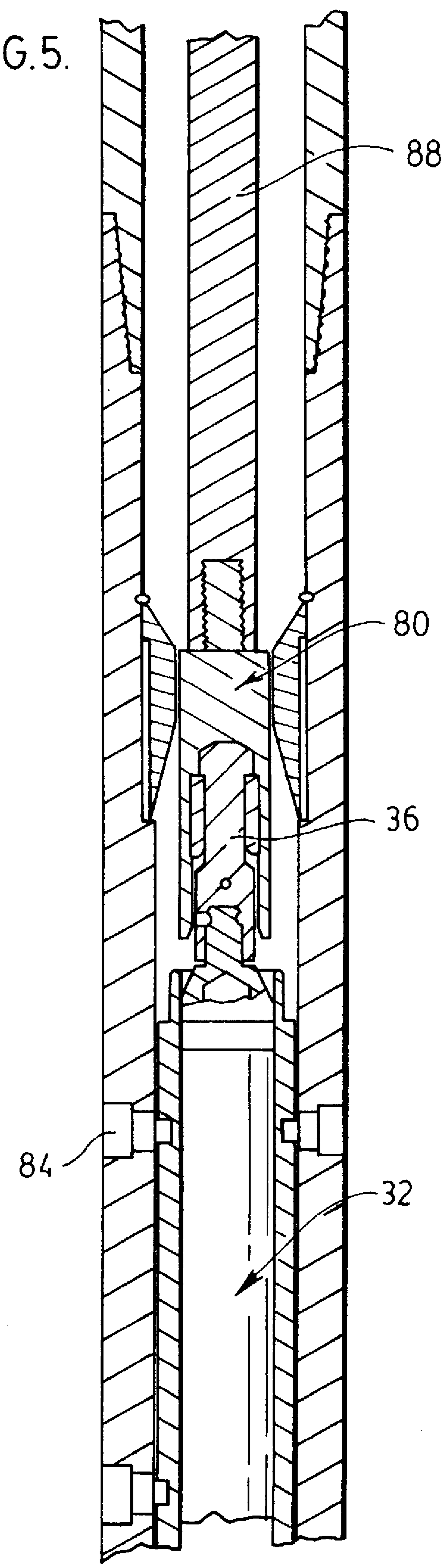


FIG.5.



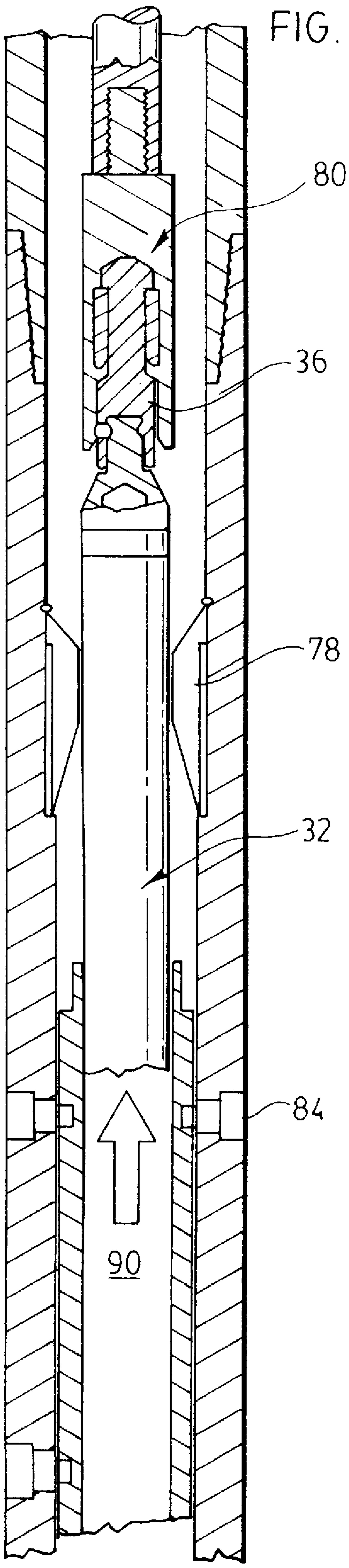


FIG. 6.

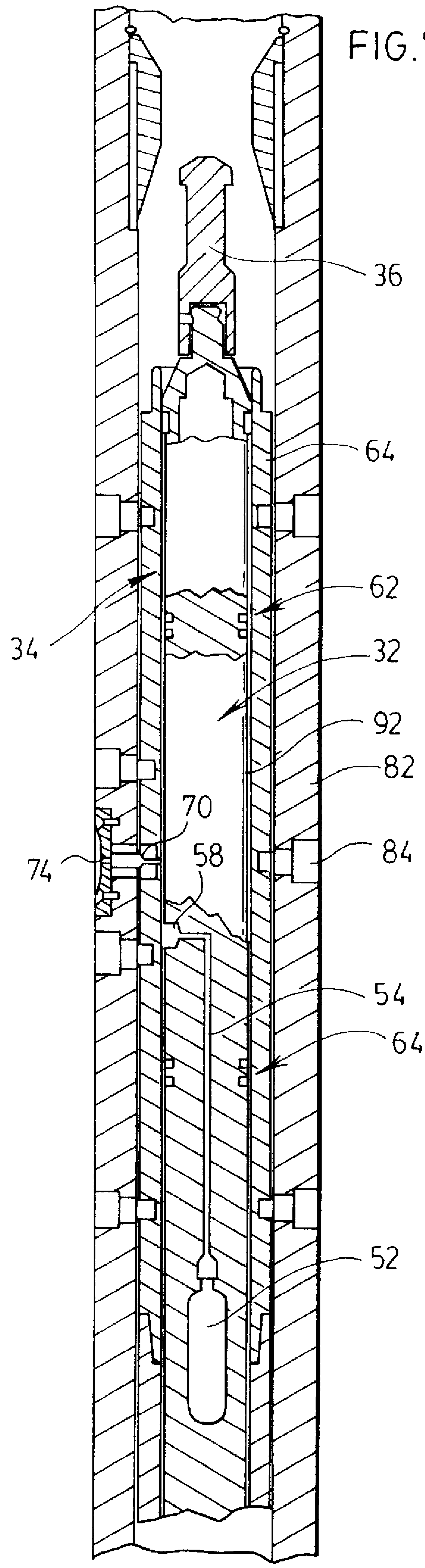
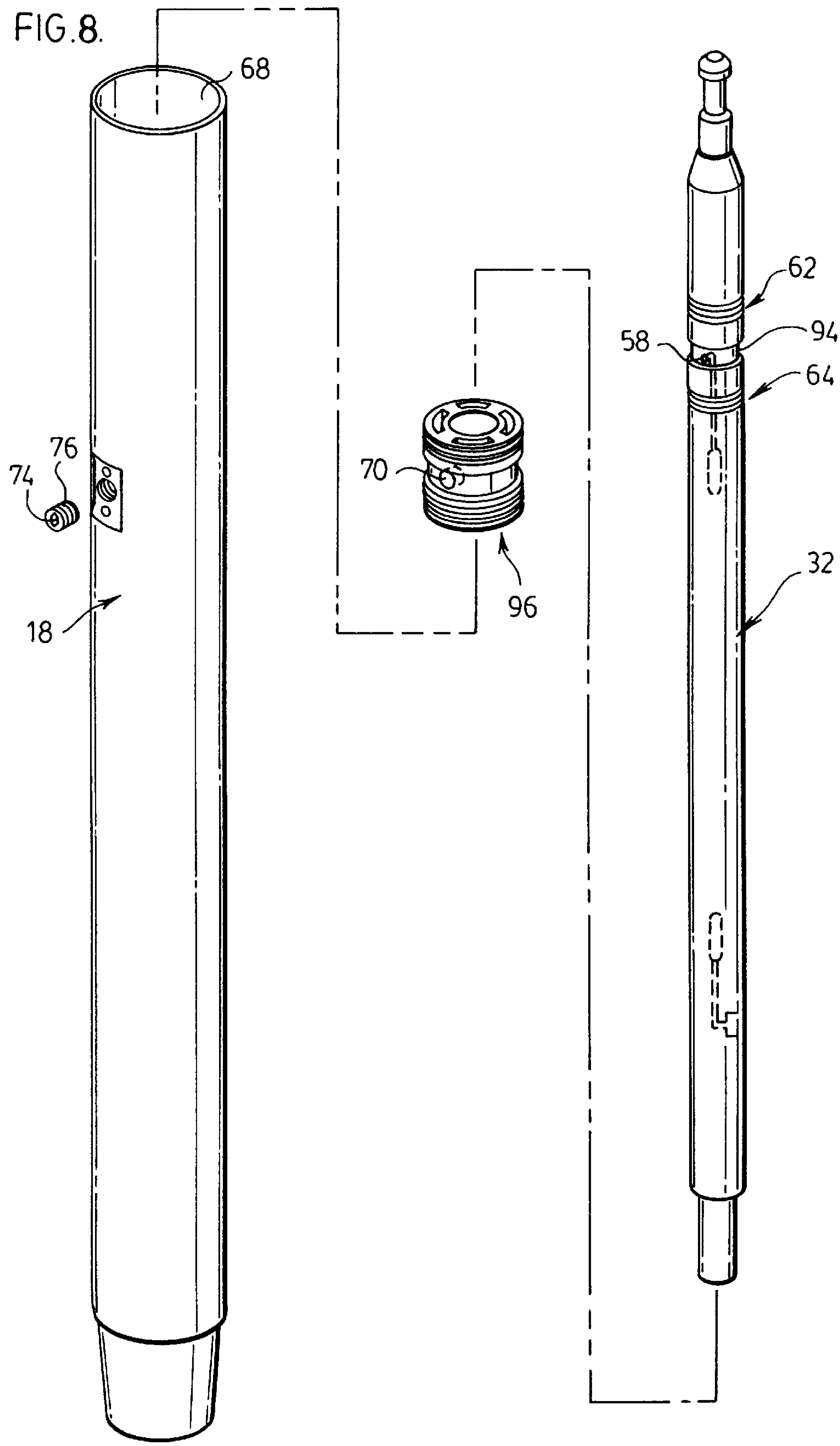


FIG. 7.

FIG.8.



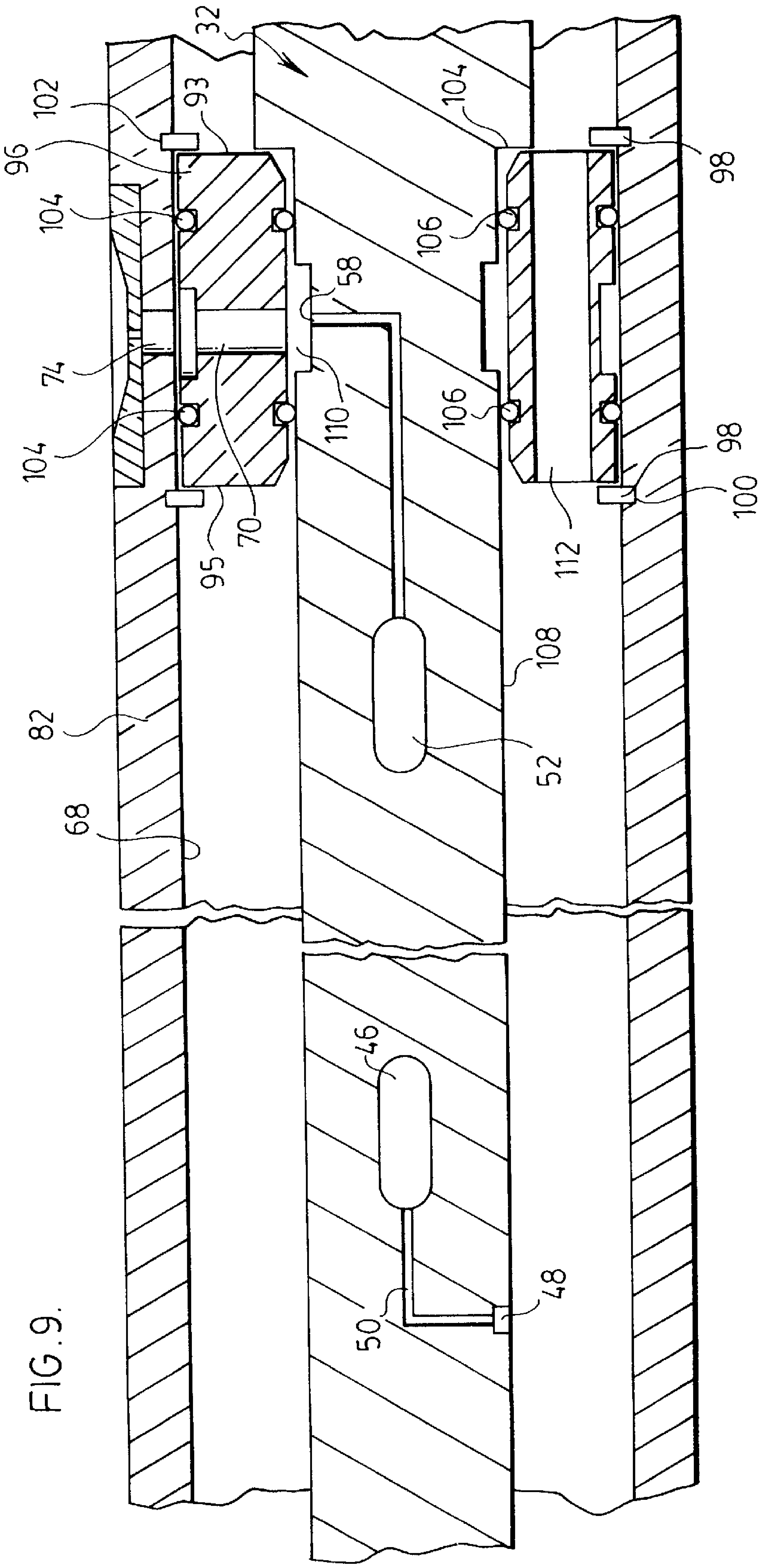

32
102
93
96
104
104
98
106
58
74
110
106
104
98
100
112
95
70
108
82
52
68
46
48
50

FIG. 9.

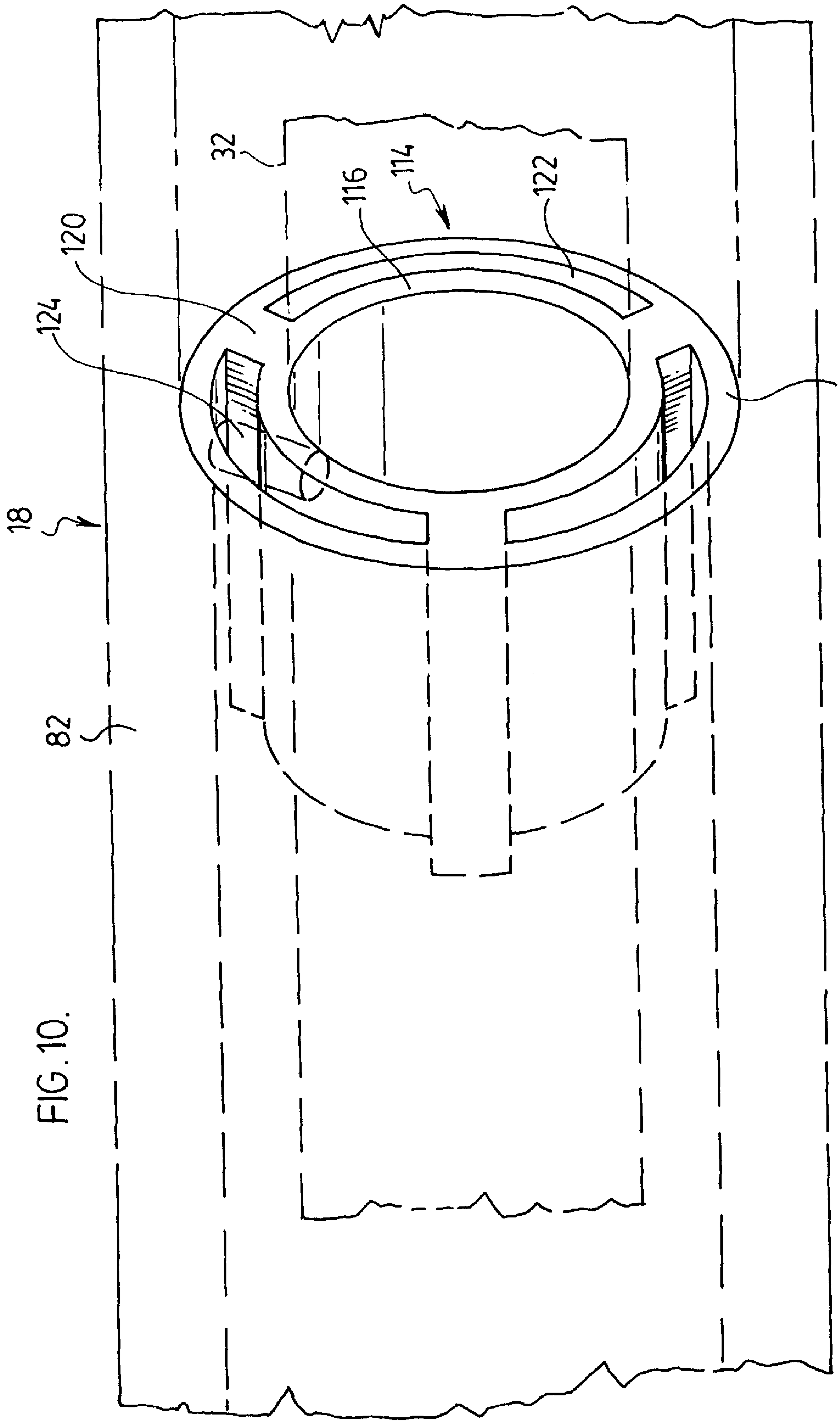


FIG. 10.

DYNAMIC PRESSURE DEVICE FOR OIL DRILL SYSTEMS

FIELD OF THE INVENTION

Petroleum exploration activities occasionally require specialized drilling techniques to optimise production from certain types of reservoir stratum. One such drilling technique is known as "underbalanced" drilling, which employs singly or a combination of nitrogen, carbon dioxide or other inert gasses, and drilling mud as the primary composite drilling fluid. In this situation, down hole pressure of the composite drilling fluid is monitored within the drill string bore and the well annulus, with the goal of preventing formation fracture due to overly high gas pressures. Another goal of underbalanced drilling is to minimise loss of the composite drilling fluid to the formation, which can be re-circulated until drilling is complete. Clearly, a specialized drilling device is needed to measure the drill string and well bore pressures to make underbalanced drilling possible.

BACKGROUND OF THE INVENTION

Although there are a variety of devices for measuring downhole drilling fluid pressure, some of the devices require a temporary cessation of drilling operations, which in some cases incur cost and time delays unacceptable to drilling operators in the competitive exploration market. Such a system is described in Canadian Patent 607,352. Other types of systems allow downhole pressure measurement while drilling, generally making use of electronic pressure measurement tools rigidly fixed to the lower portion of the drill string, near the drill bit. While satisfactory for this service, such devices are irrecoverable in the event that this section of the drill string becomes stuck downhole, and consequently abandoned if efforts to free it are unsuccessful. Typically the drill string above the stuck section is disconnected in some fashion and brought to the surface, leaving behind the drill motor, drill bit, pressure measurement tools and the lower section of the drill string. Examples of such systems are described in U.S. Pat. Nos. 4,297,880 and 4,805,449, which are capable of sensing drill bore and annulus pressure, but as mentioned are irrecoverable in the event of drill string abandonment due to their mechanical design.

There is a significant need for an electronic downhole system that measures pressure in the drill string bore and the well annulus (the area between the collar OD and the well bore), that is retrievable and re-seatable, and reports pressure measurements to the surface in a timely fashion. Such a system permits drillers to make real-time decisions on how to proceed with the drilling operation based upon this and other information. The value of such a device is greatly enhanced by providing retrieval and reseating capabilities. Retrieval permits the recovery of the device in situations where the drill string becomes stuck and must be abandoned. However, certain situations arise where the tool must be recovered temporarily and then returned to the end of the drill string so that the drilling job may be continued. This is known as re-seating, and offers a level of operational flexibility not observed in the general market for similar devices.

SUMMARY OF THE INVENTION

The Dynamic Pressure Device (DPD), in accordance with an aspect of this invention measures pressure in the drill string bore and the well annulus (the area between the collar OD and the well bore) and reports the measurement to a transmitter located within the tool string. The transmitter

communicates this information to the surface, where drillers make decisions on how to proceed with the drilling operation based upon this and other information.

In accordance with another aspect of the invention a drill string section for use in making up a drill string for oil and gas drilling is provided. The drill section carries instrumentation for Measurement While Drilling and Logging While Drilling operations, said instrumentation including a Dynamic Pressure Device for measuring drill string bore pressure of incoming pressurized drilling fluid, and drill string annular pressure of returned pressurized drilling fluid, said instrumentation being retrievable from said drill string when said drill string section is stuck or otherwise abandoned downhole, or otherwise reseatable into said drill string as required when drill string is deemed operational and fit for continued drilling. The drill string section comprises:

i) a length of drill string pipe having a bore defined by an inner surface of a pipe wall which has an outer surface,

ii) a cylindrical landing sleeve and a support for centering said sleeve in said pipe bore,

iii) communicating ports extending through said drill pipe wall from said outer pipe surface to said inner surface and through said support to an inside surface of said landing sleeve,

iv) said instrumentation being provided in an elongate cylindrical tool shell, spaced apart seals which engage said inside surface of said landing sleeve and the outer surface of said tool shell, means for locating said communicating ports between said spaced-apart seals,

v) said instrumentation in said tool shell having a first terminated passageway in said tool shell between said seals which communicates with a pressure sensor within said shell to sense thereby said drill string annular pressure,

vi) said instrumentation having a second terminated passageway in said tool shell in communication with said drill string bore and in communication with a pressure sensor within said shell whereby said drill string bore pressure is sensed.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are described with respect to the drawings wherein.

FIG. **1** is a schematic of the abandonment of a downhole drill string.

FIG. **2** is a section through the drill string of this invention.

FIG. **3** is an exploded view of the drill section FIG. **2**.

FIGS. **4**, **5**, **6** and **7** show embodiments of the invention where the pressure sensor system and related electronics can be withdrawn from the drill string when it is necessary to abandon the drill string, or alternately re-seated when required.

FIG. **8** is an exploded view of an alternative embodiment for the mounting of the pressure measurement system in the drill string.

FIG. **9** is a section through the assembly of FIG. **8**.

FIG. **10** shows yet another alternative embodiment for the mounting of the pressure measurement device within the drill string.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A representative drilling system is shown in FIG. **1**. The above ground drilling structure **10** has the usual tower **12** with drill string assembly and drive components **14**. The drill string **16** is made up of individual drill string sections **18**, the lower most of which includes a drill bit **20**. For a variety of reasons it may be necessary to abandon the downhole drill string particularly the drill string adjacent the drill bit due to the drill bit becoming stuck or otherwise seized in the formation. The abandonment of the lower most drill string can be costly because of the value of the electronic components in the tool sub-assembly which are used to provide for "measurement while drilling and logging while drilling operations". In other cases, the tool itself may fail and requires replacement. In these situations, the replaced tool must be lowered down the drill string and re-seated at its original location so that drilling operations may resume. It is understood of course that when the drill bit **20** is abandoned the operator may commence redrilling of the bore and provide for an alternate route around the abandoned drill section as indicated by the dotted lines **22**. A number of contemporary systems provide for retrieval or re-seating of the electronics in circumstances of drill string abandonment or tool replacement, however such systems are not intended or otherwise designed for measuring drill string bore pressure and drill string annular pressure.

In accordance with this invention, the system shown in FIG. **2** provides for pressure measurements and at the same time allows retrieval and re-seating of the electronic components from, and into, the downhole drill section. The upper female connector **24** of the drill string section is connected to a male threaded connector **26** of an upper drill string section. Correspondingly the male section **28** is threaded into a female section **30** of the lower drill string **18**. The electronic components for measurement while drilling and logging while drilling are housed in an elongate cylindrical tool shell **32**.

The cylindrical tool shell is positioned within a landing sleeve **34**. The cylindrical tool shell may be removed from, or installed into, the landing sleeve in the manner discussed with respect to FIGS. **4** through **7** by grasping a connector stub **36** which is secured to the cylindrical tool shell. A suitable latching mechanism **37** is provided in the drill string to releasably secure the tool shell in the drill string and locate it in the drill string. Although there are a multitude of electrical opponents within the cylindrical tool shell, the specific components of interest in respect to the invention are the devices for measuring drilling fluid pressure in the bore **38** of the tool string and drill string annular pressure in annulus **40**. The annulus **40** is defined between the earth formation **42** and the exterior **44** of the drill string section. Pressure transducer **46** is provided to measure the pressure of a circulating drilling fluid in the drill string bore **38**. A port **48** in the cylindrical tool shell communicates with a passageway **50**, and terminates at the sensor **46**. Drill string annular pressure is measured by pressure transducer **52**. Pressure sensor **52** is in communication with passageway **54**, which in turn communicates through an annular passage formed between the tool barrel and the inside diameter of landing sleeve **34** and ultimately through passageway **56**. Passageway **56** communicates with annular space **40**, noted as the drill string annular region that conveys returned drilling fluid to the surface.

Further details of the system are shown in the exploded view of FIG. **3**. The elongate cylindrical tool shell **32** has the respective ports **48** and **58** on the periphery **60** of the shell **32**. Port **48** is in communication with the pressurized fluid within the bore of the drill string section. Port **58** is located between seals generally designated **62** and **64**. The cylindrical tool shell **32** is of a dimension that readily slides through the bore of landing sleeve **34**. Seals **62** and **64** project slightly from the periphery **60** of the tool shell and form an interference fit with the interior surface **63** of the landing sleeve, the resulting seal deformation providing a liquid tight seal with the interior of the landing sleeve. Although in accordance with this embodiment, the seals are provided in the tool shell, it is appreciated that the seals may be provided in the interior surface **62** of the landing sleeve to provide a sealed space when the tool shell is inserted into the landing sleeve. The landing sleeve **34** includes supports in the form of legs **65**, in accordance with this embodiment, to space the outer periphery **66** of the landing sleeve from the interior surface **68** of the drill string section **18**. This allows the drilling fluid to flow through the spaces defined between the periphery of the landing sleeve and the interior of the drill string section. The landing sleeve **34** is secured within the drill string section in accordance with the embodiments to be discussed with respect to FIGS. **4** through **7**. In addition the leg **65** includes a port **70** which extends through the leg and the wall section **72** of the landing sleeve. The port **70** is in communication with a port **74** defined within removable plug **76**. The landing sleeve is of course fitted to the drill string section before the drill string section is put into use. When the tool shell is inserted in the landing sleeve, a suitable stop, such as the latch **37**, is provided to locate the seals **62** and **64** on opposite sides of the port **70** so that the pressurized fluid in the annulus outside of the drill string section may flow through ports **74**, **70** and **58** and through passageway **54** to the pressure transducer **52**. Seals **62** and **64** also prevent the fluid from the drill string bore, which is at a higher pressure than the annulus fluid, from leaking into the annular space **92** formed between the seals, tool barrel **32** and landing sleeve bore.

FIGS. **4**, **5** and **6** demonstrate the manner in which the cylindrical tool shell may be extracted from the drill string section **18**. On the interior surface **68** of the drill string, cams **78** are mounted on drill string interior to guide insertion of the cylindrical tool shell into the landing sleeve **34** during a seating or re-seating operation. The landing sleeve **34** has its leg portions **65** secured in the drill string wall **82** by way of bolts **84** which are threaded into the respective legs **65** in threaded bores **86**. The pressurized drilling fluid in the drill string bore flows over the tubular sleeve by way of a space defined between the interior **68** and the exterior **66** of the landing sleeve.

The extraction tool **80** is shown in FIG. **5** as having clamped onto the connector stub **36**. Extraction device **80** is connected to a wire line or the like **88**. With the extraction device clipped on to the stub **36**, the tool shell **32** may be pulled from the landing sleeve in the manner shown in FIG. **6** where the tubular shell is moving in the direction of arrow **90**. In this manner, the valuable electronic components in the cylindrical tool shell may be recovered before the drill string and drill bit are abandoned. Similarly, the cylindrical tool shell may be re-installed if the drill string and drill bit are restored to service or the electronics require servicing.

With reference to FIG. **7** the relative relationship of the exterior bore **74** to the interior bore **58** is shown. The exterior bore **74** extends through the wall **82** of the drill string section. The bore **74** communicates with bore **70** which extends through the leg **65** of the landing sleeve **34**. The bore opens up into the space defined between the exterior surface **60** of the cylindrical tool shell and the interior surface **63** of the landing sleeve. As previously explained there is a slight gap between the cylindrical tool shell and the interior of the landing sleeve to permit insertion and retraction of the cylindrical tool shell. This space is sealed off to each side of the port **70** by seals **62** and **64**. This ensures that all pressurized fluids passing through bores **74** and **70** are contained within the annular space **92**. Port **58** is in communication with the annular space **92** so that any pressurized fluid in space **92** enters port **58** and along passage **54** thereby the pressure of such fluid is sensed by the pressure transducer **52**. In this manner a reliable economical system is provided which permits measurement of drill string annular pressure while at the same time permitting extraction of the cylindrical tool shell.

An alternative embodiment for the drill string section is shown in FIG. **8**. The construction of the cylindrical tool shell **32** is essentially the same with the spaced apart seals **62** and **64**. A slight recess **94** is provided for port **58**. The landing sleeve **34** is replaced with an alternative embodiment **96** which is fixed on the interior surface **68** of the drill string section **18** by use of clip rings to be described in more detail with respect to FIG. **9**. The port **70** in the landing sleeve **96** is longitudinally aligned with the port **74** of plug **76** which can be achieved during assembly, however radial orientation of port **70** with respect to port **74** is unimportant. With reference to FIG. **9** the landing sleeve **96** is secured inside the tubular string wall **82** by way of C-clips **98** which engage the faces **93** and **95** of landing sleeve **96**. The C-clips interconnect with groves **100** and **102** in the drill string section wall. This arrangement permits the installation of the C-clips so that they can bear up against the upstream and downstream faces **93** and **95** of landing sleeve **96**.

In accordance with this preferred embodiment the cylindrical tool shell **32** has a ledge **104** which defines a stop and which abuts the upstream face **93** of the landing sleeve. Alternatively, the tool shell **32** may be located by other mechanical stops incorporated on the tool similar to other embodiments of the invention. The landing sleeve includes seals **104** to seal the exterior of the landing sleeve within the interior **68** of the drill string section. In addition to or as a replacement for the preferred embodiment showing seals **62** and **64** on the cylindrical tool shell, the landing sleeve may include seals **106** which seal to the exterior **108** of the cylindrical tool shell to ensure a leak tight connection. The port **74** which extends through the wall of the drill string section is aligned longitudinally, but not necessarily radially, with port **70** and leads into annular space **110**. Port **58** leads from pressure transducer **52** and opens into annular space **110**, permitting a reading of drilling fluid annular pressure to be made. Multiple arcuate apertures **112** provide open channels for the flow of drilling fluid along the drill string bore. In a manner discussed with respect to FIG. **2**, pressure transducer **46** communicates with port **48** through passageway **50** permitting a pressure measurement of the drill string bore fluid to be made.

With reference to FIG. **10**, an alternative embodiment for the landing sleeve is shown. In this embodiment the landing sleeve is integral with the drill string section **18** and its wall section **82**. The landing sleeve **114** is machined as part of the drill string bore during the fabrication process. The landing sleeve wall **116** is spaced from the interior wall **118** of the drill string by circumferentially arranged legs **120**. The landing sleeve **114** has arcuate shaped channels **122** which extend through the landing sleeve **114** and provide the necessary flow paths for the pressurized drilling fluid. The landing sleeve **114** has the port **124** extending from the exterior of the drill string section through the wall **82** through the leg **120** and through the wall **116** of the sleeve. The cylindrical tool shell **32** may be constructed in the same manner as that of FIG. **3** so that the seals **62** and **64** are positioned to each side of the port **124**. This provides, as

discussed with respect to the prior embodiments, for the usual communication of pressurized drilling fluid on the exterior of the drill section to within the system for measurement by the pressure transducer **52**.

Accordingly, various embodiments are provided which demonstrate the effectiveness of a landing sleeve in providing for annular pressure measurements of drilling fluid, and at the same time providing for a retraction or re-seating of the cylindrical tool shell while the drill string is down hole.

Although preferred embodiments of the invention have been described herein in detail, it will be understood by those skilled in the art that variations may be made thereto without departing from the spirit of the invention or the scope of the appended claims.

What is claimed is:

1. A drill string section for use in making up a drill string for oil and gas drilling, said drill string section carrying instrumentation for Measurement While Drilling and Logging While Drilling operations, said instrumentation including a Dynamic Pressure Device for measuring drill string bore pressure of incoming pressurized fluid and drill string annular pressure of returned pressurized fluid, said instrumentation being retrievable from said drill string when said drill string section is stuck or otherwise abandoned downhole, said drill string section comprising:

i) a length of drill string pipe having a bore defined by an inner surface of a pipe wall which has an outer surface,

ii) a cylindrical landing sleeve and a support for centering said sleeve in said pipe bore,

iii) communicating ports extending through said drill pipe wall from said outer pipe surface to said inner surface and through said support to an inside surface of said landing sleeve,

iv) said instrumentation being provided in an elongate cylindrical tool shell, spaced apart seals which engage said inside surface of said landing sleeve and the outer surface of said tool shell, means for locating said communicating ports between said spaced-apart seals,

v) said instrumentation in said tool shell having a first terminated passageway in said tool shell between said seals which communicates with a pressure sensor within said shell to sense thereby said drill string annular pressure,

vi) said instrumentation having a second terminated passageway in said tool shell in communication with said drill string bore and in communication with a pressure sensor within said shell whereby said drill string bore pressure is sensed.

2. A drill string of claim **1** wherein said landing sleeve comprises a hollow cylinder with said support being support legs extending in a length direction along said cylinder, said legs being adapted for securement to said inner diameter of said drill pipe and fasteners for securing said legs to said drill pipe.

3. A drill string of claim **1** wherein said landing sleeve comprises a hollow cylinder with support legs extending in a length direction along said cylinder, said support legs and said hollow cylinder being integral with said drill pipe section.

4. A drill string of claim **1** wherein said landing sleeve comprises a hollow cylinder with support legs extending in a length direction along said hollow cylinder, said support legs and said hollow cylinder being integral, said landing sleeve being positioned in said drill string by C-clips engaging said drill string and located on each side of said cylinder.

5. A drill string of claim **1** wherein each of said seals for said cylindrical tool shell, each seal is a ring seal of compressible material which permits said cylindrical shell to slide within said landing sleeve.

6. A drill string of claim **1** wherein each of said seals is provided on said inside surface of said landing sleeve.

7. A drill string of claim **1** wherein said cylindrical shell has at its upstream end, a coupling component for connection to an instrumentation retrieval device to permit withdrawal of said instrumentation from stuck or other abandoned drill string section.

8. A drill string of claim **2** wherein two or more opposing support legs are provided on said hollow cylinder, each support leg being of a thickness to provide an annulus of sufficient cross-section to accommodate typical flow rates of drilling fluid along said drill pipe bore.

9. A drill string of claim **8** wherein each of said legs have a plurality of threaded bores which are aligned with apertures in said drill pipe wall, said fasteners extending through said apertures and being threaded into said threaded bores to secure said legs to said inner surface.

10. A drill string of claim **2**, wherein said legs are releasable from said fasteners to be removable from said

hollow cylinder, said communicating ports extending through one of said legs.

11. A drill string of claim **1** wherein said pressure sensors are pressure transducers secured in said cylindrical tool shell.

12. A drill string of claim **1** wherein an annular space is provided in said cylindrical tool shell, said annular space being formed between said spaced apart seals and communicating with said first terminated passageway in said cylindrical tool shell, and said annular space aligned with said communicating ports to complete communication between outside said drill string pipe to said pressure sensor regardless of radial orientation about a longitudinal axis of said cylindrical tool shell.

13. A drill string of claim **1** wherein said drill pipe includes on said inner diameter and upstream of said landing sleeve a guide for guiding insertion of said cylindrical tool shell into said landing sleeve.

* * * * *